Improved Information Systems for Mine Burial Prediction

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Award Number: N00014-01-1-0376

LONG-TERM GOALS

Improve the quality, availability and reliability of seabed information for modellers, decision makers, and units operating at sea. That information includes data on seabed firmness, mobility, composition.

OBJECTIVES

(i) Improve the delivery of data on the character of the seabed for use in mine burial prediction, and other naval and scientific endeavours. Particularly, to improve techniques of mapping in the spatially and temporally complicated coastal zone, preferably using unsupervised techniques.

(ii) Improve the delivery of indexes of the reliability for seabed data, with development of appropriate visualizations of uncertainties.

[This report address the Post-Graduate Research Degree component at the University of Sydney. Other components there and at the University of Colorado were completed by 2002.]

APPROACH

Using satellite and aerial imagery of Australian wave- and storm-prone coastal areas, investigate a variety of image segmentation/classification techniques in GIS and other application environments. During the investigation, establish: (i) the suitability of the techniques for reliable classification of imagery, for instance into sand, rock and mud substrates, (ii) whether they can be implemented for semi-automated classifications on regional scales, (iii) rational and effective ways of combining results that use different properties of image segments.

WORK COMPLETED

Pre-processing of the images was done to remove sun-glint and other extraneous effects before these methods were applied. An extensive set of data has been examined using aerial photographs taken over several decades and representing a range in photographic quality. Image classification was achieved

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **30 SEP 2004**	2. REPORT TYPE	3. DATES COVERED **00-00-2004 to 00-00-2004**

4. TITLE AND SUBTITLE **Improved Information Systems for Mine Burial Prediction**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **INSTAAR, University of Colorado,,Boulder,,CO,80309**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**5**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

using histogram clustering on a range of image properties such as color, texture. The number of classes to be distinguished was kept low in order to begin with good reliabilities.

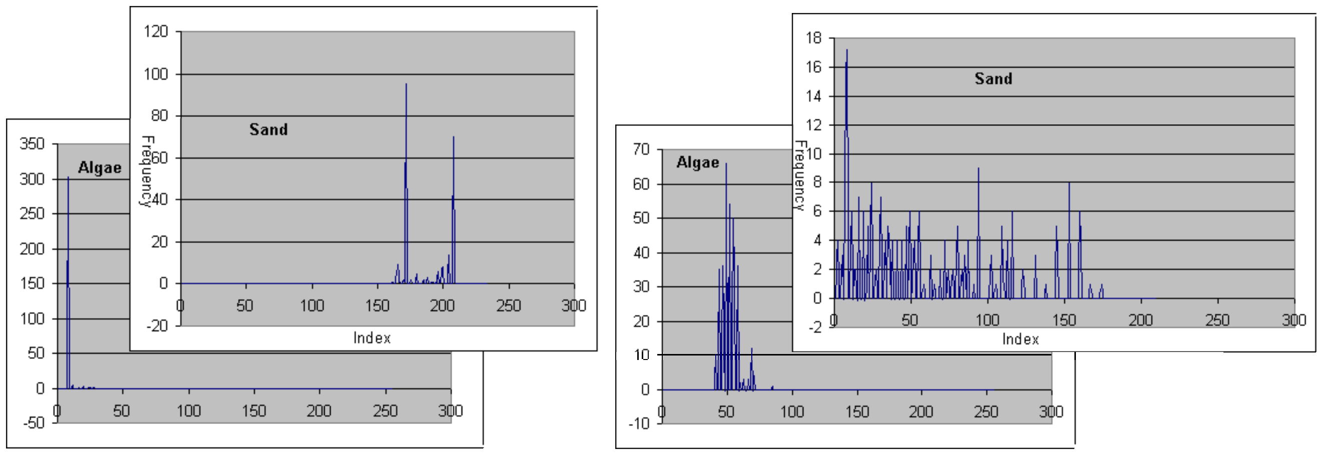

Fig. 1 Clustering values for image segments classed as sand and algae. a. RGB color; b. texture.

Figure 1 shows some statistical results from two image segmentation processes. Color cluster analysis creates one value per pixel based on a combination of the RGB values and then identifies cluster values based on statistical frequency peaks. Sand cluster values (indexes) range from ~160 to 210 whereas seaweed beds, have very low cluster values <40, but mostly <10. These contrasting cluster values become one of our key indicators in identifying bottom type in an image. Color clustering is only one of the "unlocking mechanisms" in seabed classification. Texture analysis for each pixel, reports on the character of the neighbouring pixels. Potentially uniform classes, such as sand and water, are separated from more dynamic environments, such as algal beds, rocks and the breaker zone. Texture analysis values are complex for sands, usually within 0 to 50, but extending significantly to >150. Modeling this distribution in order to make texture a workable identifier for sand will be a challenge. For algally colonized areas there is a well defined pattern, for which even a normal distribution would suffice. However the size of the dataset for this environment is small, decreasing the reliability of the modeled distribution. Areas known to be rocky substrate were often characterized by a biologically colonized algal signature. Linearity analysis, which gives important definition of breakerzones, strandlines, dunes, and human habitation, completes a trilogy of useful image properties.

Synthesis. Methods have been developed which combining this "trilogy" of clusterings into an overall classification. The clustered color, texture and linearity distributions are converted to calibrated membership functions associated with fuzzy sets for 'sand', 'rock', etc. Areas of mixed character will be permitted to have a membership of several classes at once. To conclude the project, the distributions will be tested on other sets of imagery (including satellite), and will be presented in the form of computer programs with documentation, thesis and papers.

RESULTS

The development has been able to produce an automated classification of the substrates in coastal surf-prone areas. Results have shown that the top three most differentiated results came from image analysis based on spectral clustering, texture analysis, and linearity analysis.

IMPACT/APPLICATIONS

Coastal classification is an important issue right now, not only for operational (mapping) purposes, but in vew of predicted sealevel rise. Remote image coastal classifications will be needed to predict the worldwide impacts on communities, landscapes, and other factors like carbon budgets and fluxes.

TRANSITIONS

Regional scale remote coastal classifications are required in seafloor mapping projects at navy labs and in research, for example to provide a boundary condition on machine mappings of shallow marine bottom type. Within the dbSEABED network, the work is likely to be used by the Australian Navy, the USGS, German institutions, and universities.

RELATED PROJECTS

Seafloor mapping of the US EEZ and other areas (JENKINS: Williams et al. 2003); Surfzone Morphodynamics (SHORT); Completion of Australian Beach Database (SHORT, in press b: Mundy 2002).

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PATENTS

(No data)

HONORS/AWARDS/PRIZES

(No data)